

# Workshop on Cold Neutron Chopper Spectrometer

## NIST

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# The Silicon Backscattering Spectrometer at SNS

K. W. Herwig

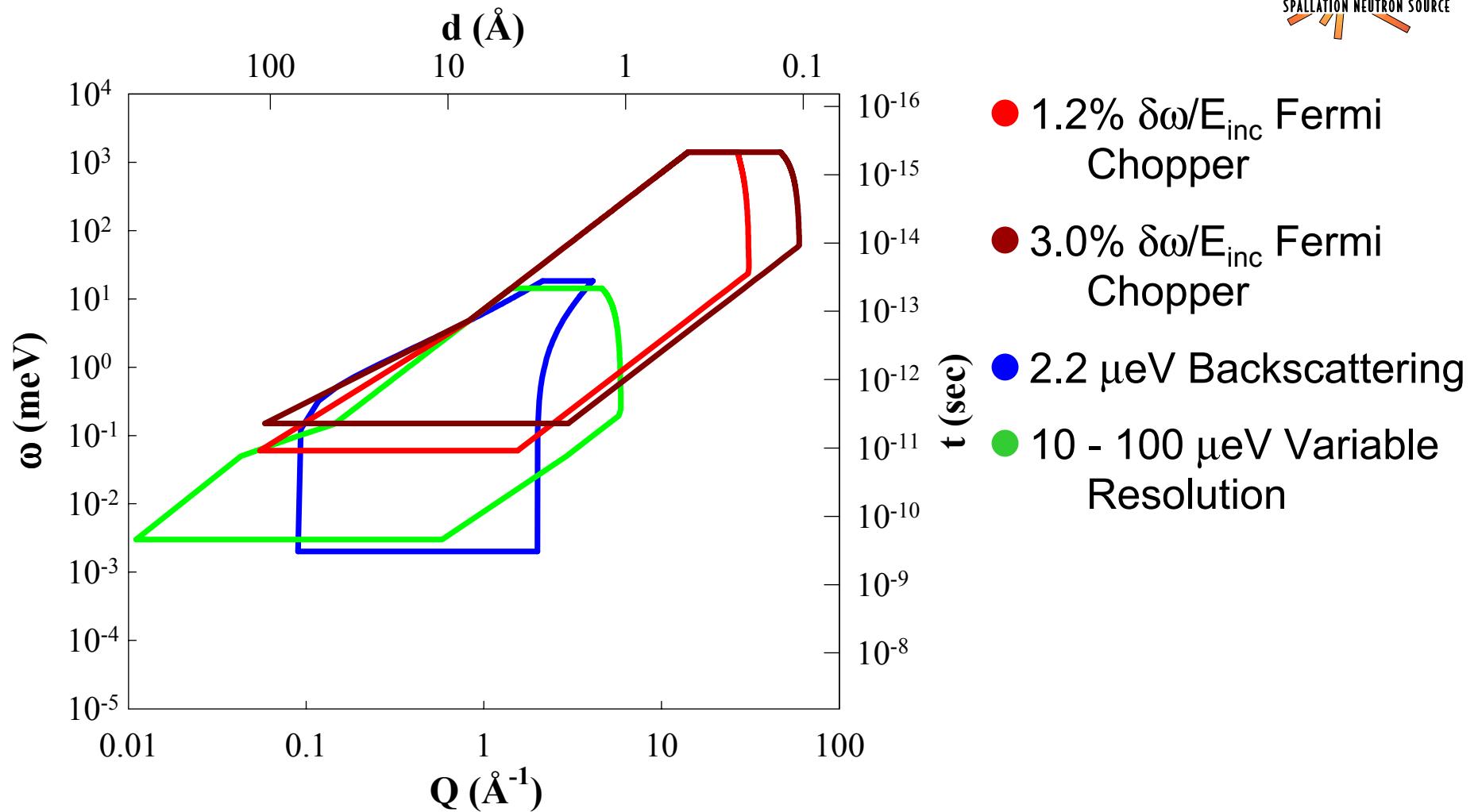
*Instrument Scientist*

SNS

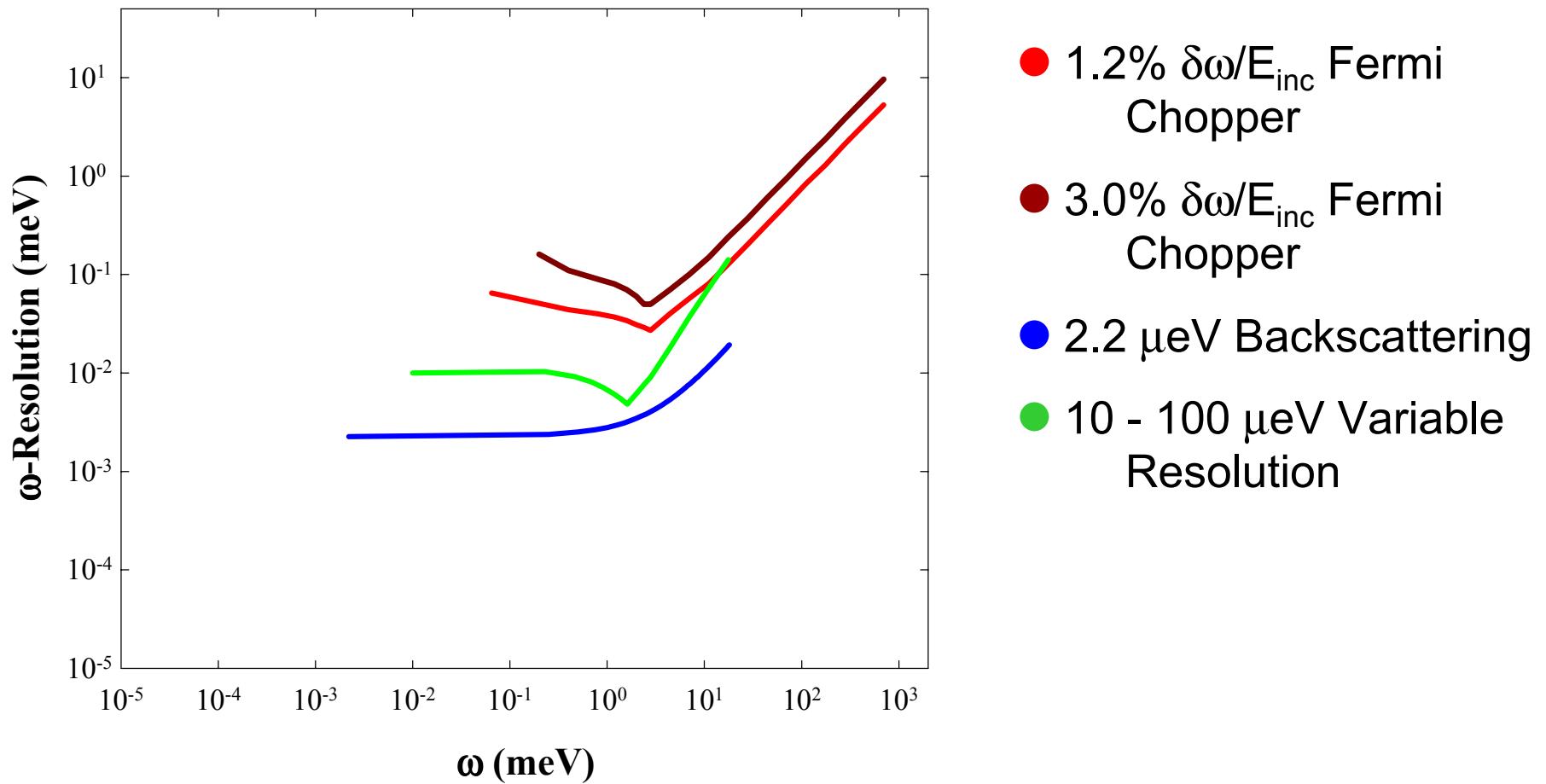
*Oak Ridge National Laboratory*

May 21-22, 2001

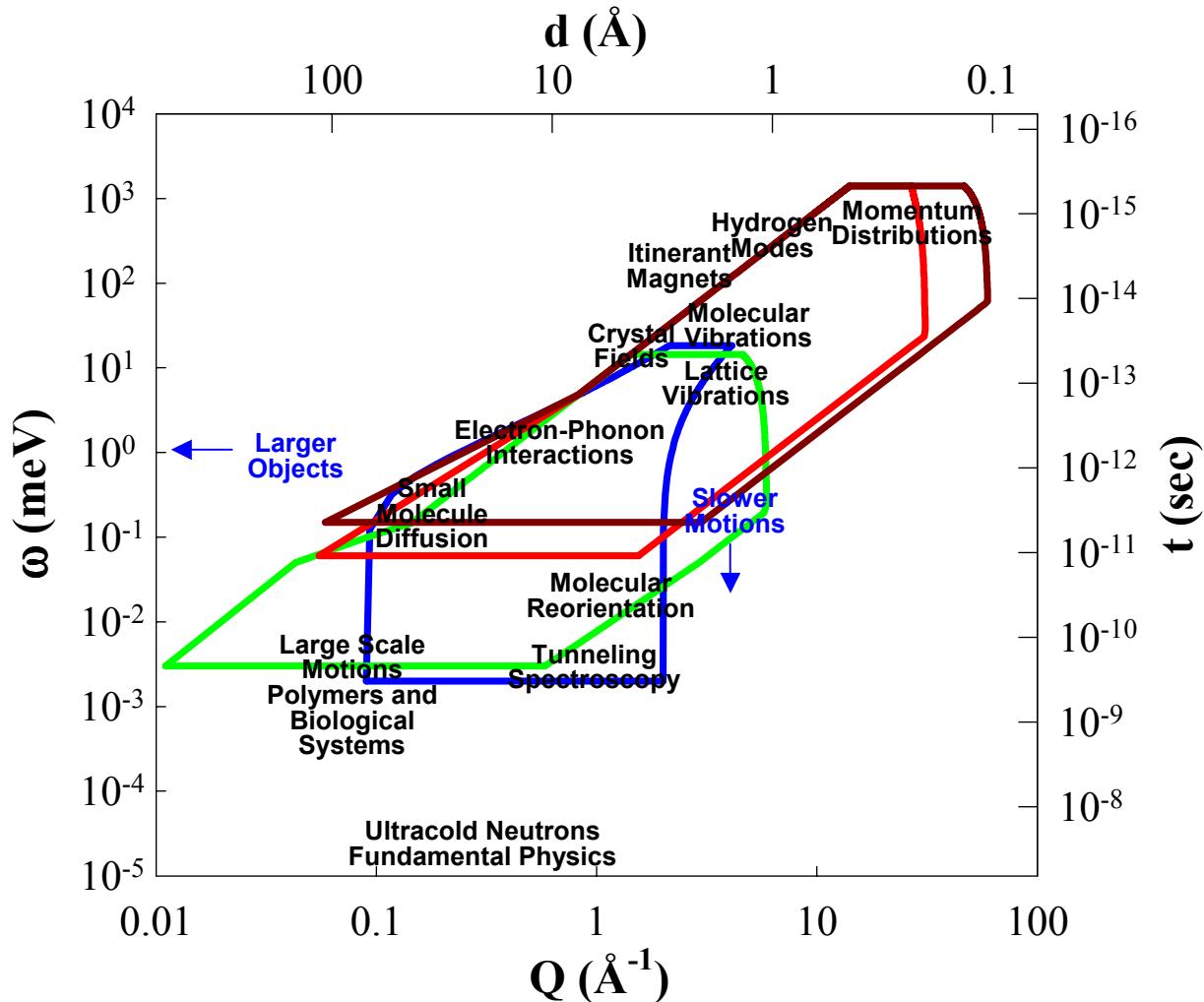
# Q- $\omega$ Space Accessible with Proposed HPTS Spectrometers



# $\omega$ - Resolution



# Q- $\omega$ Space Science



- 1.2%  $\delta\omega/E_{\text{inc}}$  Fermi Chopper
- 3.0%  $\delta\omega/E_{\text{inc}}$  Fermi Chopper
- 2.2  $\mu\text{eV}$  Backscattering
- 10 - 100  $\mu\text{eV}$  Variable Resolution

adapted from "Neutron Scattering Instrumentation for a High-Powered Spallation Source" R. Hjelm, et al., LA0-UR 97-1272

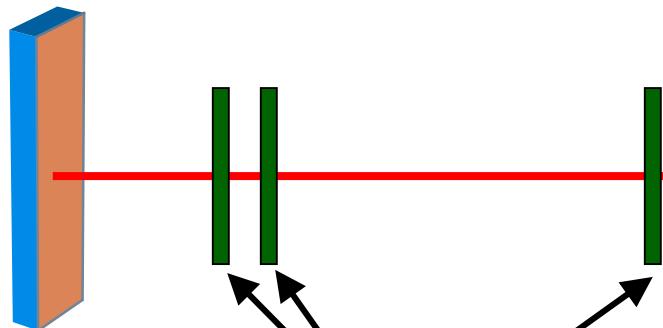
# Crystal Analyzer Spectrometers



Pulsed Source

Moderator  $t_0(\lambda)$

Incident flight path  $L_i$



Bandwidth Choppers

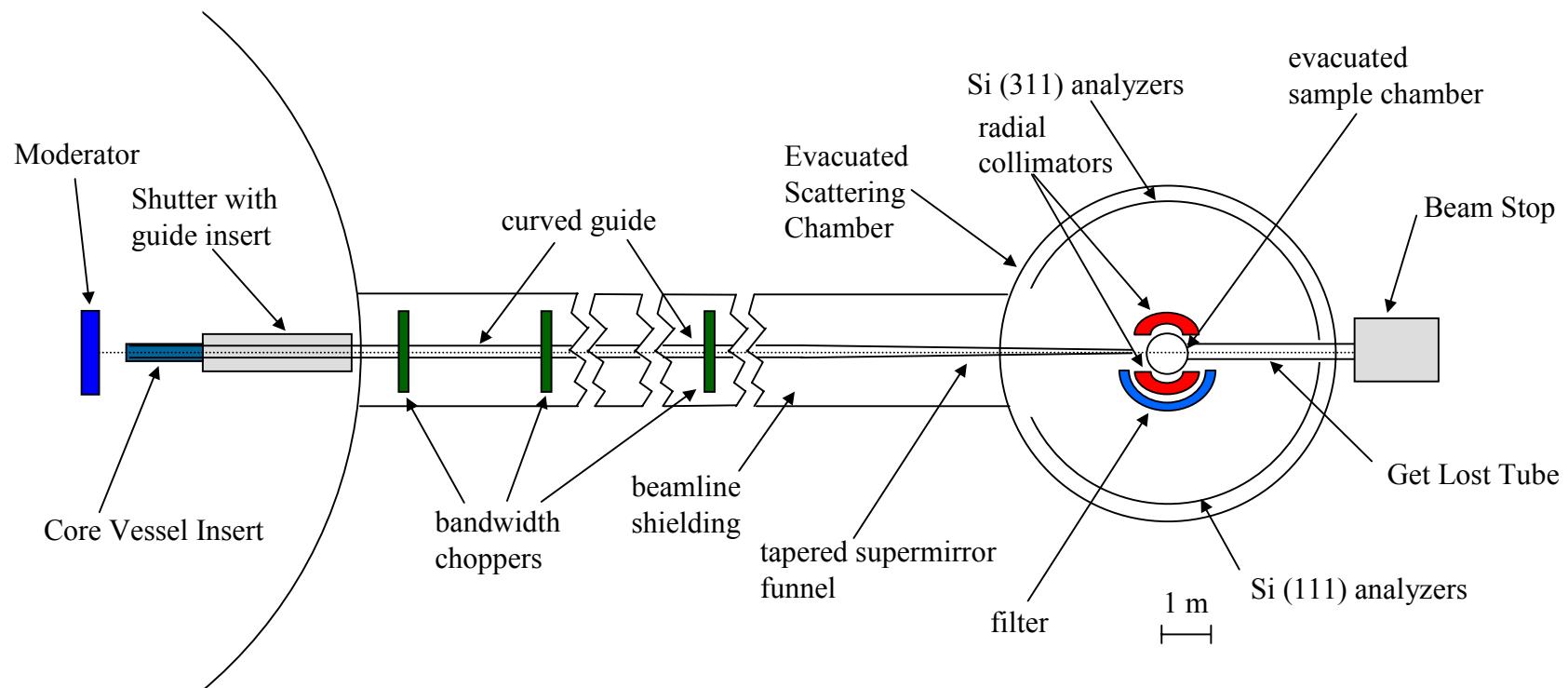
Final flight path  $L_f$

Sample

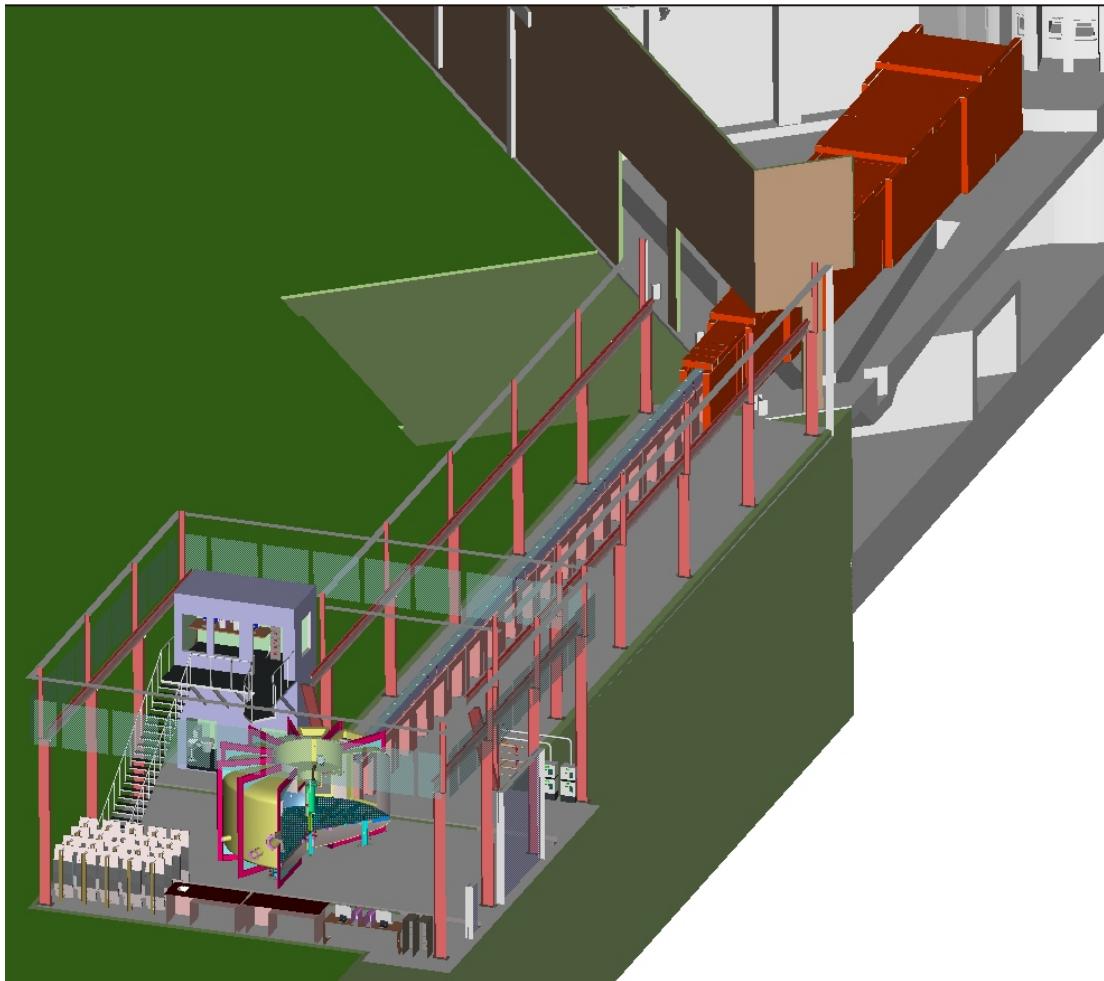
Detector

Analyzer Crystals  $\Delta d/d, \lambda_f$

# Major Spectrometer Components

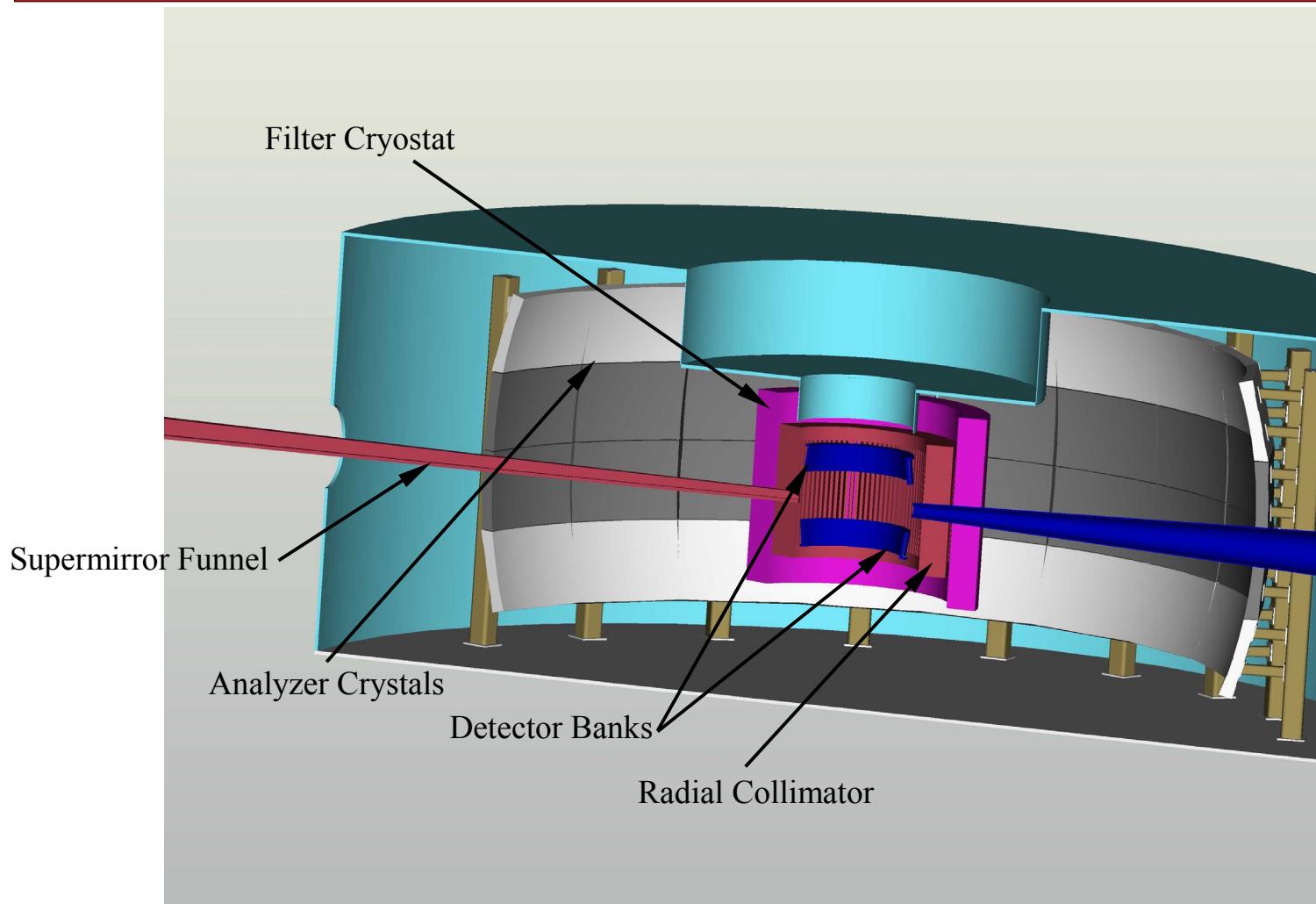


# Beam Path for the Backscattering Spectrometer

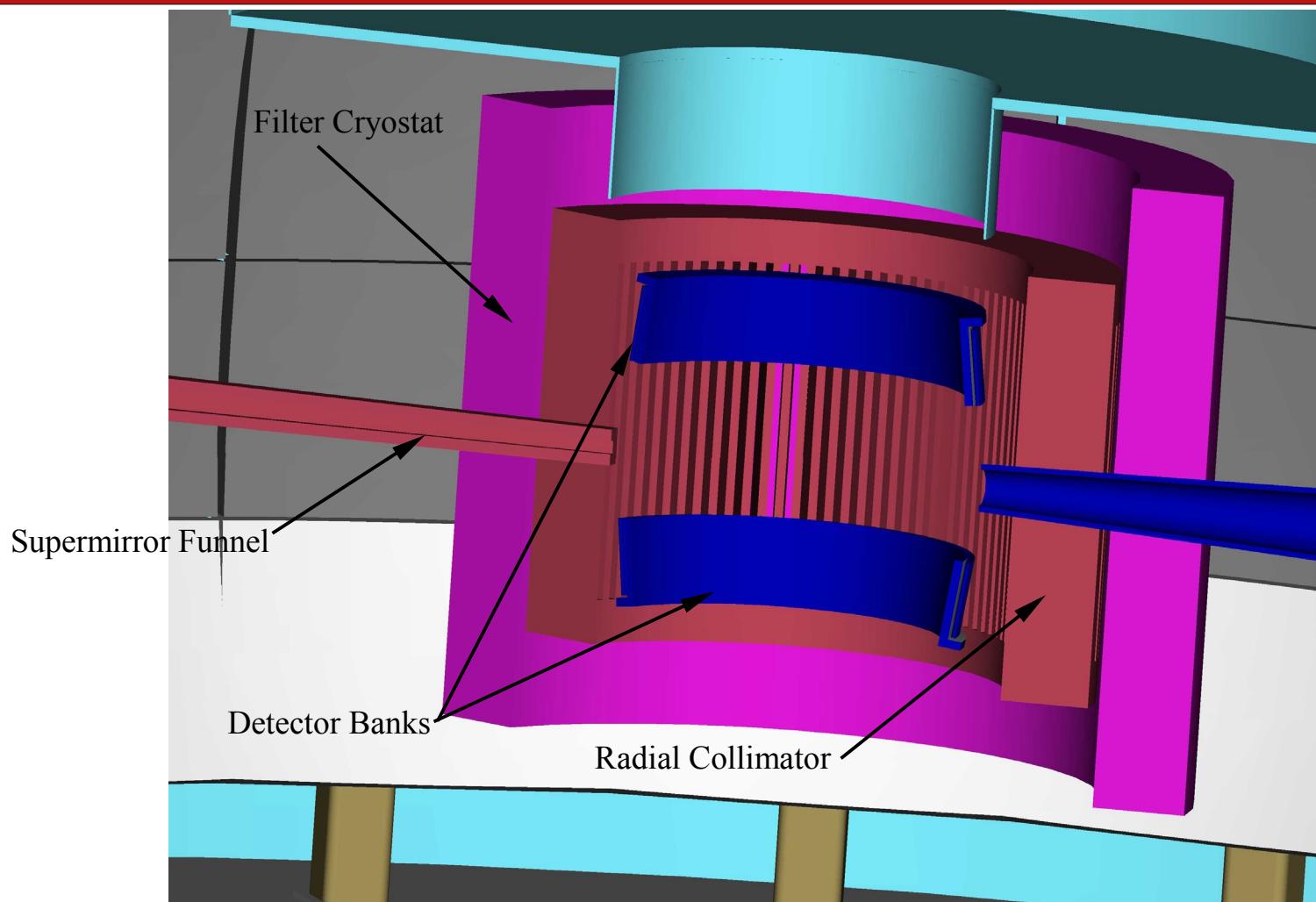


- 84 m incident flight path
- Si (111) analyzer crystals
- Elastic Resolution 2.7  $\mu\text{eV}$
- Dynamic Range  $\pm 260 \mu\text{eV}$
- $0.1 \text{ \AA}^{-1} < Q < 2.0 \text{ \AA}^{-1}$
- $-0.3 \text{ meV} < \omega < 18 \text{ meV}$
- Up to 100x performance of current instruments

# Cross Section Elevation View of the Scattering Chamber



# Close up view of the Detector, Radial Collimator, and Filter Cryostat



SNS Experimental Facilities

Oak Ridge National Laboratory

# Performance Summary



## Near Elastic Performance

Analyzer Crystal	$\lambda_f$ (Å)	$\Delta\lambda$ (Å)	$\omega$ -range (μeV)	$\delta\omega$ (fwhm) (μeV)	$Q$ -range (Å <sup>-1</sup> )	$\delta Q$ (fwhm) (Å <sup>-1</sup> )
Si (111)	6.267	0.785	$-258 < \omega < 258$	2.2	0.1 – 2.0	0.05 – 0.03
Si (311)	3.273	0.117	$-279 < \omega < 279^*$	10	0.2 – 3.8	0.05 – 0.03

\*If sample upscattering is not a problem, the Si (311) dynamic range can extend to  $\pm 1700$  μeV.

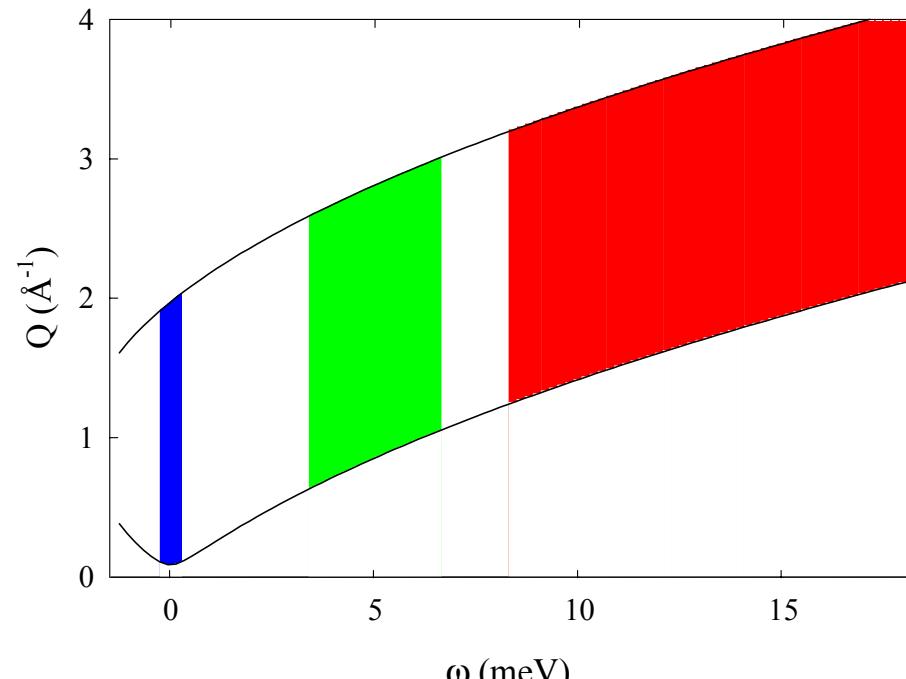
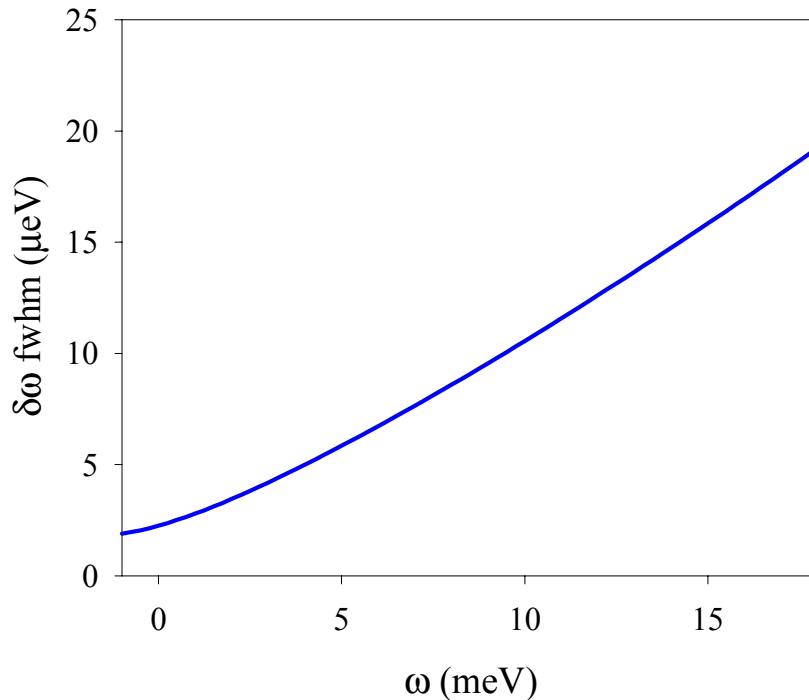
## Inelastic Performance Si (111)

$\omega$ (meV)	$\omega$ -range (meV)	$\Delta\omega$ (fwhm) (μeV)	$Q$ -range (Å <sup>-1</sup> )
0	$-0.258 < \omega < 0.258$	2.2	0.1 – 2.0
1.0	$0.538 < \omega < 1.464$	2.8	0.2 – 2.2
2.0	$1.30 < \omega < 2.70$	3.5	0.4 – 2.4
5.0	$3.42 < \omega < 6.59$	5.8	0.9 – 2.8
10.0	$6.55 < \omega < 13.46$	10.6	1.4 – 3.7

# Instrument Resolution and $Q$ - $\omega$ Range for HPTS Backscattering



- Elastic Resolution as low as  $2.2 \mu\text{eV}$  (fwhm)



# Science Enabled

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- Quasielastic Scattering:
  - Translational diffusion (self diffusion coefficients as slow as  $10^{-7}$  cm<sup>2</sup>/sec)
  - Rotational motions (correlation times to 100's psec)
- High Intensity can be used for parametric studies
- Very small samples
  - $10^{-4}$  moles H-atoms
  - high pressure
  - shear, 1 micron thick hydrogenous samples
- Materials other than H-atoms, ionic diffusion
- Dilute systems
- Tunneling
- Spectroscopy to  $\omega \approx 18$  meV, with 0.1% resolution

# Summary

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- The High Resolution Backscattering Spectrometer
  - Si (111)
    - Elastic Resolution =  $2.2 \text{ }\mu\text{eV}$  (fwhm),  $-258 \text{ }\mu\text{eV} < \omega < 258 \text{ }\mu\text{eV}$ ,  
 $0.1 \text{ \AA}^{-1} < Q < 2.0 \text{ \AA}^{-1}$ , Inelastic to 18 meV with  $\delta\omega = 0.1\% \omega$ .
  - Si (311)
    - Elastic Resolution =  $10 \text{ }\mu\text{eV}$  (fwhm),  $-1700 \text{ }\mu\text{eV} < \omega < 1700 \text{ }\mu\text{eV}$   
 $0.2 \text{ \AA}^{-1} < Q < 3.8 \text{ \AA}^{-1}$
  - Very high count rates (small samples, dilute systems, weakly scattering isotopes) Expect approximately 15 minutes or less as average count time for 10% scattering sample.